Farklı Kanal Dolgu Maddelerinin ve İrrigasyon Solüsyonlarının Mikrosızıntı Değerlendirilmesi

Comparative Evaluation of Microleakage for Different Root Canal Sealers and Irrigation Solutions

Dolgu Maddeleri ve İrrigasyon Solüsyonları / Root Canal Sealers and Irrigation Solutions

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Özet

Amaç

Bu çalışmanın amacı, hangi irrigasyon solüsyon hangi kanal dolgu patıyla birlikte kullanılırsa en az mikrosızıntının oluşacağını tespit etmektir.

Gereç ve Yöntemler

Bu çalışma için 170 tek köklü maksiller ve mandibuler anterior insan dişi seçildi. Kök kanalları HERO-Shaper ile crown-down tekniği kullanılarak genişletildi ve % 5.25 NaOCl ile yıkandı. Smear tabakası 10 ml % 17 EDTA ile yıkanarak kaldırıldı. Örnekler her grup rastgele 10 dişten oluşacak şekilde 16 gruba (kanal dolgu maddeleri; Sealite-Ultra, Diaket, AH-Plus, Ketac-Endo and irrigasyon solüsyonları; NaOCl, %2 CHX, %1 CHX gel+NaOCl, % 1 CHX gel+SF), 5 dişten oluşacak şekilde 2 kontrol gruba bölündü ve lateral kondansasyon yöntemiyle dolduruldu. Sıvı transport metodu ile sızıntı miktarları hesaplandı ve kaydedildi. Daha sonra her gruptan 4 örnek seçilip SEM (scanning electron microscope)'de incelendi.

Bulgular

En az sızıntı Ketac-Endo ile %2 CHX solüsyonunun birlikte kullanıldığı uygulamada görüldü. Çalışmamızda kullanılan kök kanal dolgu patları arasında istatistiksel olarak önemli bir fark tespit edilmemiş olup, irrigasyon solüsyonları arasında ise NaOCl solüsyonu %1 CHX Gel+SS ve %1 CHX Gel+NaOCl solüsyonlarından daha fazla sızıntıya neden olmuş ve aralarındaki fark istatistiksel olarak da anlamlıdır.

Sonuç

Bu çalışma sonucunda kullanılabilecek tüm dolgu patları için en iyi yıkama solüsyonlarının %1 CHX+SF ve %1 CHX+NaOCl oldukları görülmektedir.

Anahtar Kelimeler

Mikrosızıntı, Sıvı Transport Metodu, İrrigasyon Solüsyonu, Kanal Dolgu Maddesi, Scanning Electron Microscope, Klorheksidin (CHX) Jel.

Abstract

Aim

The aim of the study was to examine the sealing ability of a root-canal sealer using different endodontic irrigants and to measure the microleakage using a fluid transport model.

Material and Methods

170 maxillary and mandibular anterior human teeth with single bilnded were selected for this study. The root canals were instrumented using the crown-down technique with HERO-Shaper and were irrigated with 5.25 % NaOCl. The smear layer was removed by washing in 10 ml of 17% EDTA. The specimens randomly divided into 16 groups (root-canal sealings; Sealite-Ultra, Diaket, AH-Plus, Ketac-Endo and irrigation solutions; NaOCl, 2 % CHX, 1% CHX gel+NaOCl, 1% CHX gel+SS) of ten teeth and two control groups of five teeth and obturated by lateral condensation. In order to measure the microleakage, a fluid transport model was used and leakage value for each group was calculated and recorded. Four specimens from each group were used for SEM examinations (scanning electron microscopy).

Results

The best results are taken when Ketac-Endo with 2% CHX solution used. The results proved that there is no significant difference between root-canal sealers. As for irrigant solutions, NaOCl solution caused more microleakage than 1% CHX Gel+SS and 1% CHX Gel+NaOCl solutions and the results are statistically significant.

Conclusion

The study shows that the best irrigant solutions for all root-canal sealers are 1% CHX+SS and 1% CHX+NaOCl.

Keywords

Microleakage, Fluid Transport Model, Irrigation Solutions, Root Canal Sealer, Scanning Electron Microscopy, CHX Gel.

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Introduction

The aim of the endodontic treatment is to prevent microleakage by filling the canals with nontoxic seals, after mechanical removal of all organic materials inside the root canal system and cleaning with nonirritant bactericide solutions [1].

For the removal of organic materials, the most commonly used instruments are canal files and chemical irrigation materials. Irrigation is the most effective method for removal of residual tissue and dentin debris during the instrumentation. Sodium Hypochlorite (NaOCl) and Chlorhexidine Gluconate (CHX) solutions are the most commonly used irrigation solutions [2]. NaOCl is an irrigant especially preferred for its antimicrobial effect, and lubrication and tissue dissolving properties; but it is found that it causes strong inflammatory reaction when come into contact with vital tissues [3].

CHX is a cationic bisbiguanide agent with pH between 5.5 and 7.0, low toxicity. Despite its routine usage at periodontal treatment and cavity prevention, its gel and liquid forms are used as irrigation solutions at endodontic treatment [4]. Gel form of CHX has low toxicity on periapical tissues. Its viscosity helps to maintain its activity when come into contact with the walls of root canals and dentine tubules. It is also fully soluble in water [5].

There are many endodontic filling materials with different property that are used as canal sealer. Those provide apical sealing to be successful via different filling techniques [6]. Although the most commonly used filling material is gutta-percha, it is used together with different canal sealers in order to hermetically seal the space between gutta-percha and root walls, and dentine canals [2]. Among those, the ones gained common acceptance are glass ionomer-based sealers [Ketac-Endo], calcium hydroxide-based sealers [Kalsin, Sealapex], zinc oxide-eugenol-based sealers [Sealite-Ultra] and polymer sealers [AH-Plus, Diaket].

As the penetration property of root canal sealer increases, the sealing ability also increases [3]. There are many methods used to assess the sealing ability of root canal sealers, some are impermeability test [7], liquid transport method [8], radioactive isotope method [9] and bacterial penetration test [10]. Among these, the liquid transport method is an accurate method, which allows the assessment of microleakage levels at different times, because it can measure microleakage without disturbing the original sample [10].

The aim of this study is to determine the best canal root sealer and irrigant solution combination in order to achieve the least microleakage. To do this, we compared the results of possible combinations.

Material and Methods

During this study, 170 maxillary anterior human teeth, extracted cause of orthodontics and periodontics, with single and straight root canals, were selected.

Root canal preparation and filling: Selected teeth with open roots apices, cracks and resorptive defects were excluded. The teeth were carefully cleaned with curettes to remove soft-tissue remnants and were stored in saline solution before instrumentation. The crowns of the teeth were sectioned at the cemento-enamel junction using water-cooled diamond disks. A #15 K file (Antaeos, VDW GmbH, München, Germany) was inserted into the canal to measure the working length and to verify the apical patency. The working length was established 1 mm short of the apex. The root canals were prepared by using crown-down technique with HERO Shaper (Micro-Mega, Besancon Cedex, France). The coronal third of each root was flared up to a 2-4 Gates Glidden bur (Dentsply, Maillefer, Switzerland) with a low-speed hand-piece. The canals were irrigated with 5.25 % NaOCl that was delivered with a dental syringe, using 2ml between each file size. After instrumentation, the smear layer was removed with 10 ml 5.25 % NaOCl, 10 ml 17 % EDTA (Hacettepe University, School of Pharmacy) and 10 ml 5.25 % NaOCl for 2 min in the respective sequence. Final irrigation of all root sections was carried out with 10 ml saline solution (SS), and the canals were dried with sterile paper points (Meta Dental Co., Ltd., Korea). 160 prepared teeth were randomly divided into 16 groups (n=10/ groups) and the remaining 10 teeth were divided into 2 groups of negative and positive controls (n=5/groups).

The groups were treated with the following irrigant solutions and root-canal sealers:

1)	2 ml of 5.25% NaOCl and Sealite-Ultra
2)	5.25% NaOCl and AH-Plus
3)	5.25% NaOCl and Diaket
4)	5.25% NaOCl and Ketac-Endo
5)	2% CHX gel and Sealite-Ultra
6)	2% CHX gel and AH-Plus
7)	2% CHX gel and Diaket
8)	2% CHX gel and Ketac-Endo
9)	1% CHX gel-5.25% NaOCl and Sealite-Ultra
10)	1% CHX gel-5.25% NaOCl and AH-Plus
11)	1% CHX gel-5.25% NaOCl and Diaket
12)	1% CHX gel-5.25% NaOCl and Ketac-Endo
13)	1% CHX gel-SS and Sealite-Ultra
14)	1% CHX gel-SS and AH-Plus
15)	1% CHX gel-SS and Diaket
16)	1% CHX gel-SS and Ketac-Endo.

In groups 1-4, 2ml of 5.25% NaOCl was applied as an irrigation solution while in group 2 specimens were irrigated with 2 ml of 2 % CHX solution (Drogsan, Ankara, Turkey).

In groups 9-16, 1% CHX gel (Hacettepe University, School of Pharmacy) was applied into the root canals as an intra-canal medicament. Root canals were filled with gel using a lentulo. Root canal openings were sealed with cotton pellets and a temporary filling material. Specimens were then stored at 37C° and 100% humidity for 1 week. Following the period, in groups 9-12 10 ml of 5.25% NaOCl was applied for 2 minutes to remove CHX gel from root canals, while 10 ml sterile saline solution was applied for groups 13-16.

Root canals of the samples were obturated using cold lateral condensation technique with gutta-percha cones (Diadent ML. 029, Korea) and 4 different sealers Sealite-Ultra (Produits Dentaires Pierre Rolland, Cedex, France), AH-Plus (Dentsply DeTrey, Konstanz, Germany), Diaket (3M ESPE AG, Seefeld, Germany) and Ketac-Endo (3M ESPE AG, Seefeld, Germany) was applied into channel after mixing with lentulo as recommended by the producer. After obturation, hot pluggers were used to remove the excess gutta-percha from the orifices of the root-canal. Five roots obturated with gutta-percha without any sealer were completely coated with two layers of nail varnish except for the apex of the root and the coronal access and were used as the positive controls. Five root sections obturated with gutta-percha cones and sealers were completely coated with two layers of nail varnish and served as negative controls. All samples were stored in sterile saline solution at 37 ºC for 2 weeks. The irrigation solutions used in the experimental groups are listed in Table I.

Evaluation of Microleakage by Fluid transport model: The method is fluid transport model used. The coronal end of the obturated root was then connected to a plastic tube filled with deionized water. Water was sucked back with the syringe for approximately 3 mm in the open end of the glass capillary and then connected to a piece of plastic tube filled with water. In this way, an air bubble was created in the capillary. A head-space pressure of 10 kPa (0.1 atm) from the coronal side was applied and the water was forced through the voids along the root canal filling, displacing the air bubble in capillary tube by transport of water. The volume of the fluid transport was measured in millimeters by observing the movement of this air bubble, and the mean leakage value for each group was calculated and recorded.

Evaluation of Scanning Electron Microscope (SEM): Four specimens from each group were used for SEM examinations (Jeol, JSM-6400, Tokyo, Japan). Longitudinal grooves were cut at the buccal and lingual surfaces of the roots. The roots sections were carefully separated from each other with a sharpened blade. The specimens were mounted on stubs, put in a vacuum chamber, sputter-coated with gold-palladium for SEM evaluation. These samples were examined using SEM to assess dentin tubule penetration at magnifications of 2.500 times. SEM values of examination groups were not evaluated by any statistical test.

Statistical Analysis: A 95% confidence interval was adopted for the descriptive statistics. The effects of irrigant solutions and root-channel sealers on microleakage were measured using General Linear Model–GLM. Pairwise comparisons made using Bonferroni post-hoc test to measure effect of irrigant solutions on microleakage. For statistical analyses, SPSS for Win. Ver. 15.00 (SPSS Inc. Chicago, IL., USA) package program was used. The required level for statistical significance is taken as $p \leq 0.05$.

Table 1. Leakage Amount of Solutions Respective to Filling Materials

Root-Canal Sealings	Irrigation Solutions	Amount of Microleakage		
		Average (mm)	Lower Bound	Upper Bound
SEALITE-ULTRA	NaOCl	1.050	0.529	1.571
	2% CHX SOL.	1.500	0.979	2.021
	1% CHX GEL+SS	0.700	0.179	1.221
	1% CHX GEL+NaOCl	0.900	0.379	1.421
AH-PLUS	NaOCl	1.300	0.779	1.821
	2% CHX SOL.	1.400	0.879	1.921
	1% CHX GEL+SS	0.700	0.179	1.221
	1% CHX GEL+NaOCl	0.900	0.379	1.421
DIAKET	NaOCl	1.700	1.179	2.221
	2% CHX SOL.	1.000	0.479	1.521
	1% CHX GEL+SS	0.800	0.279	1.321
	1% CHX GEL+NaOCl	0.600	0.079	1.121
KETAC-ENDO	NaOCl	1.600	1.079	2.121
	2% CHX SOL.	0.400	0.000	0.921
	1% CHX GEL+SS	0.500	0.000	1.021
	1% CHX GEL+NaOCl	0.500	0.000	1.021

Results

The microleakage measurements for different canal root sealer and irrigant solution combinations are listed in Table 1.

When Table 1 were analyzed, we see that the best combination for least microleakage is the Ketac Endo (Figure 1) root-canal sealer and 2% CHX solution. The worst results are taken when Diaket root-canal sealer and NaOCl solution combination used. Besides, Graph 1 shows that better solutions for all sealers are %1 CHX+SS

Table 2. The Bilateral Comparison of Microleakage Amounts Respective to Washing Solutions.

(I) group	(II) group	Mean Difference (I-II)	Std. Error	p	95% Confidence Interval for Difference	
					Upper	Lower
NaOCl	2% CHX SOL.	0.338	0.186	0.434	0.000	0.836
	1% CHX GEL+SS	0.738	0.186	0.001	0.239	1.236
	1% CHX GEL+NaOCl	0.688	0.186	0.002	0.189	1.186
2% CHX SOL.	1% CHX GEL+SS	0.400	0.186	0.202	0.000	0.899
	1% CHX GEL+NaOCl	0.350	0.186	0.375	0.000	0.849
1% CHX GEL+SS	1% CHX GEL+NaOCl	-0.050	0.186	1.000	0.000	0.449

and %1 CHX+NaOCl.

When pairwise comparisons was made via Bonferroni post-hoc test to reveal the cause of microleakage differences between irrigant solutions; the difference between NaOCl, 1% CHX gel+SS and 1% CHX gel+NaOCl is statistically significant ($p<0.05$). But, the microleakage difference between other solutions are insignificant ($p>0.05$). The results are given in Table 2. When results in Table 2 analyzed, it was seen that although NaOCl 0.338 caused more microleakage, the statistical relevancy between the results of NaOCl and 2% CHX is higher (p= 0.434). NaOCl solution caused more leakage than 1% CHX gel+SF and 1% CHX gel+NaOCl solutions, and the difference shows statistical significance (p= 0.001, p= 0.002). No statistical relation was found between other solutions in context of microleakage.

When the amount of microleakage is taken as dependent variable, and sealers and solutions are taken as independent variables, Univarite GLM analysis shows that there really is a statistically significant relation ($p<0.001$) between solutions and the amount of microleakage. Yet there is no meaningful relation ($p>0.05$) between microleakage and sealer or sealer-solution combination. The model designed with univarite GLM analysis explains the changes at the amount of microleakage with 60% relativity (R2=0.599).

The SEM evaluation showed that both irrigation solutions have better adaptation and penetration in coronal and middle thirds compared to the apical third of root canal. SEM evaluation also showed that AH-Plus performs better than other root-canal sealers as dentin tubule penetrator (Figure 2). As for irrigant solutions, 1% CHX gel had performed better penetration to dentin tubule (Figure 3), but NaOCl and SS solutions, which was used to infuse the solution into canal, were failed to completely remove the gel from tubule.

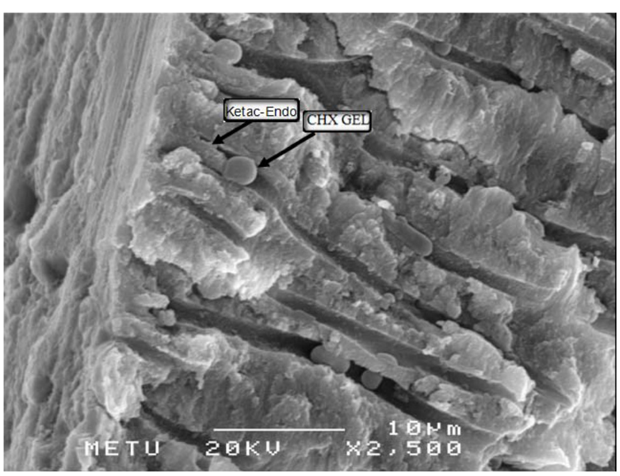

Figure 1. SEM Image of Ketac-Endo with the worst tubular penetration (X 2,500 magnification).

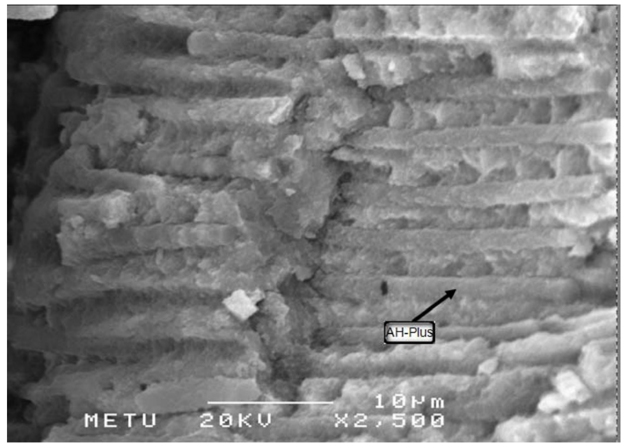

Figure 2. SEM Image of the AH-Plus root canal sealing with best tubular penetration (X 2,500 magnification).

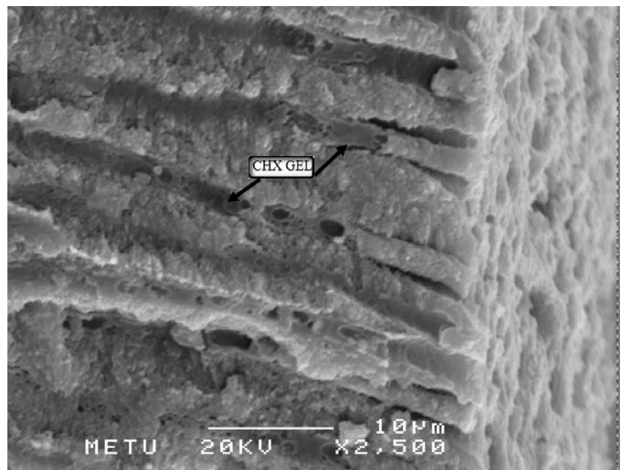

Figure 3. SEM Image of tubular penetration of CHX gel (X 2,500 magnification).

Discussion

Our study is more widely than former studies, since we compared different combinations of four irrigant solutions and four root canal sealers. As CHX gel is soluble in water, it can easily be removed from canals when washed with distilled water [5]. Practical properties of CHX gel, such as antimicrobial activity, low toxicity, solubility and removal of smear layer, increases its preferability as endodontic irrigant [11,12].

Ferraz et al. [5] stated that when used for irrigation, CHX gel provides long-term antimicrobial effect and lubricates root canals. Besides they stated that tissue dissolving effect, which is nonexistent in CHX solution, can be compensated by gel implementation owing to the increased viscosity, thus dentine debris inside root canals can removed more easily. During the study, CHX gel was applied to root canals with 26 gauge needle. They observed that gel does not penetrate and stays on wall, and when washed with distilled water, it can easily be removed from canal.

Yet Çal [13] used distilled water and NaOCl to remove the CHX gel applied to root canal via lentulo tubule during tubular penetration experiment he conducted. He stated that distilled water is far more effective than NaOCl at removing gel from canal, but he also stated that both solutions are inadequate.

But we preferred saline solution and NaOCl to remove the gel applied to root canal via lentulo. Although serum physiologic proved to be more successful than NaOCl at removing the CHX gel from root canals, both irrigant failed to completely remove the gel from canals.

Kruvilla and Kamath [14] observed during their study on 1% NaOCl and 2% CHX gel [viscous form] combination that NaOCl first disintegrated to H^+, O^{-2} and Cl^- ions and then formed chlorhexidine chloride (N^+ Cl^-) after reaction of chloride group with chlorhexidine. Gomes et al. [12] stated that viscous dark-brown production is fast during this reaction. They stated that, since viscous dark brown can easily adhere to dentine and root walls, it can not be completely removed from root canals, so it creates a residual film and that can increase microleakage by marring the filling property of sealer.

We also observed the reaction and formation of viscous dark-brown, when we mixed 1cc CHX gel and 0.1cc NaOCl in an injector. This formation remained unchanged for 10 days, afterwards viscous formation decomposed. Former studies [12,14] explained the inadequacy of serum physiologic and NaOCl at removal of CHX gel with viscous dark-brown formation. So our study supports former results.

Various studies speculated that irrigant solutions as well as canal sealers causes microleakage. Gomes et al. [2] used five different irrigant solutions (I-1% NaOCl, II- 1% NaOCl+17% EDTA, III- 2% CHX gel, IV- 2% CHX gel+1% NaOCl, V-distilled water) during their study on the effect of irrigant solutions on microleakage. According to their results, the best results were recorded with 2nd and 3rd group solutions and worst results were recorded with 4th group solutions. But they couldn't find statistically significant difference between groups. In short, they reported that CHX gel doesn't damage the sealing ability of root canal sealers.

During our study, we observed the minimum microleakage levels in CHX gel-SS and CHX gel-NaOCl groups. Although the results of SEM and microleakage experiments are consistent with previous literature [2], the results recorded in CHX gel-SS group were better that CHX gel-NaOCl group. But the difference between the groups was not statistically significant.

There are studies in the literature, in which various canal sealers were inspected for microleakage. Miletić et al. [15] compared five different root canal sealers [Ketac-Endo, AH-26, AH-Plus, Apexit and Diaket]. Although they observed the microleakage levels were best in Ketac-Endo group, the difference with other sealers was not statistically significant. Çobankara et al. [16] studied four different root canal sealers [AH-Plus, Ketac-Endo, RoekoSeal, Sultan]. The microleakage experiment conducted using liquid filtration model showed that Sultan causes much more microleakage than RoekoSeal [polydimethylsiloxane], Ketac-Endo and AH-Plus, and the difference was statistically significant. Koch et al. [17] stated that Ketac-Endo has better filling property than zincoxide eugenol-based filling materials [sultan, sealite-ultra]. The microleakage study conducted by Rohde et al. [18] showed that zinc oxide eugenol based filling materials causes more apical leakage that Ketac-Endo. Finally De Gee et al. [19] stated that the impermeability property of epoxy resin based filling materials [Diaket] are better than glass ionomer based canal filling materials [Ketac-Endo].

The best results were observed in Ketac-Endo group and the worst results were observed in Sealite-Ultra group. But the hermetic property of Ketac-Endo was not statistically significant respective to AH-Plus and Diaket. Ketac-Endo has better hermetic property than other canal sealers [17]. Also our study confirms the results of prior studies. Better results recorded in Ketac-Endo group may be related more to better chemical binding to dentine than better tubular penetration. We believe that AH-Plus resulted worse because of short implementation time and high shrinkage stress.

The penetration of root canal sealers is crucial in contest of coronal and apical microleakage for the success of endodontic treatment [20]. The study of Leblebicioğlu et al. [21] explored whether dentine tubule penetration and microleakage are relevant. They observed that the removal of smear layer facilitates the penetration of root canal sealer into dentine tubule and also increases the effectiveness of sealing, consequently decreasing coronal and apical leakage. In the study of Şen et al. [22], where the effect of the tubule penetration of sealings on paint leakage, they found a reverse correlation with low quality between penetration and microleakage.

Similarly our study also showed bad tubular penetration but highest microleakage results for Sealite-Ultra. But although Ketac-Endo did not present so good tubular penetration results, it presented the lowest microleakage results.

In the study of Leblebicioğlu et.al [21], where the tubular penetration of Ketac-Endo was examined, they observed that the tubular penetration was bad for lateral condensation group whereas adaptation to canal walls and penetration to dentine tubules was good for single cone group. They stated that they believed this is due to short hardening time for Ketac-Endo. Also in our study, tubular penetration was quite bad when canals were filled using lateral condensation technique.

Pecora et al. [2 3] stated that AH-Plus has a good value for adhesion but low value for tubular penetration. Differently than others, in our study, AH-Plus homogeneously spread to dentine canals despite its granular composition. Big particles couldn't penetrated whereas small particles penetrated into almost every dentine tubule up to 30-40μm deep. We believe this is due to implementation technique.

Okşan et al. [24] examined the tubular penetration of four different canal sealer [Diaket, Forfenan, SPAD, N2 Universal] and concluded Diaket to be better than SPAD and N2, and Forfenan to be the worst. Şen et al. [22] studied the correlation between microleakage and dentine tubular penetration for four different root canal sealer [Diaket, CRCS, Endomethasone, Ketac-Endo], during the study they filled canals with vertical condensation technique after removing smear layer. The paint leakage evaluation showed that Diaket presents least leakage, and Diaket, CRCS and Endomethasone have good tubular penetration. Contrary our study showed that although Diaket has low microleakage, its tubular penetration is low. We believe these contradictive results to be due to different canal filling techniques and leakage measurement methods.

In our SEM study, CHX gel could penetrate into root canals up to 40 µm deep when applied with lentulo and the reaction between CHX gel and NaOCl was minimal. This is why; we didn't observe any viscous dark-brown formation inside dentine tubules. But as CHX gel groups filled dentine tubules well, they couldn't be removed after the last wash with NaOCl or SS. Besides, these groups presented relatively less microleakage because of better tubular penetration ability of root canal filling material. Among different solution and filling material combinations, the best results for microleakage were observed in Ketac Endo-2% CHX group, and the worst results were observed in Diaket-NaOCl and Sealite Ultra-NaOCl groups. The SEM study of the same groups presented better results for Sealite Ultra-NaOCl group than Ketac Endo-2%-CHX and Diaket-NaOCl groups. Furthermore the best results in context of tubule penetration were observed in AH-Plus groups.

Conclusion

We conclude that the effectiveness of irrigant solutions and root canal sealers in context of microleakage and tubular penetration is affected by implementation technique as well as their chemical and physical properties. Our study proves that the best solutions for all sealers are 1% CHX+SS and 1% CHX+NaOCl. According to the results, NaOCl and 2% CHX causes more microleakage and should be used with caution.

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